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MOUNTAIN PINE BEETLE ASSESSMENT FOR THE VAIL VALLEY AREA OF COLORADO

May 1997

Prepared by:

Roy A. Mask
Leader
Gunnison Service Center

Tom J. Eager
Entomologist
Gunnison Service Center

Approved by:

Robert D. Averill
Group Leader
Forest Health Management

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MOUNTAIN PINE BEETLE ASSESSMENT FOR THE VAIL VALLEY AREA OF COLORADO

This assessment is a cooperative effort between the Town of Vail, the Colorado State Forest Service and the USDA Forest Service.

I. INTRODUCTION

The mountain pine beetle (MPB) (*Dendroctonus ponderosae*) is native to the lodgepole pine forests of the western United States. Mountain pine beetle populations periodically reach epidemic proportions and kill significant numbers of large diameter lodgepole pine (Cole and Amman 1969). During severe epidemics, the overstory of entire stands may be killed. One immediate result of beetle epidemics is the reduction in the average (living tree) stand diameter (Schmid and Mata 1996). Mountain pine beetle activity also influences stand structure and composition, which impacts such things as canopy closure, forage production, wildlife habitat, fire hazard, water yield and aesthetics. The frequency of mountain pine beetle epidemics/outbreaks for an area of lodgepole pine may vary from approximately 20 to 40 years, depending on the rate of tree diameter growth (Amman 1977).

Many factors contribute to the initiation of mountain pine beetle outbreaks, although the exact triggering mechanism(s) is not known. The condition of host stands and their location on the landscape are very important. Stress factors such as drought and lightning may contribute significantly to stand susceptibility and they are often implicated in bark beetle outbreaks. Another very important factor is the status of the beetle population. Bark beetles are subject to a number of mortality factors including microclimate, parasites, predators and disease. When factors favorable to population increases and host susceptibility coincide, beetle outbreaks can result.

The lodgepole pine forests of the White River National Forest have a long history of mountain pine beetle activity. Beetle outbreaks from 1910-12 and from 1944-45 in the areas of Summit and Eagle Counties caused concern among local residents and resource professionals (Angwin 1996). As of the 1960's, entomologists noted that lodgepole pine stands covering vast portions of the White River National Forest and surrounding lands were becoming increasingly susceptible to bark beetle attack (Angwin et al. 1996). Following an evaluation in 1967, D.A. Hester noted that beetle populations were low, but that monitoring should be increased and infested trees should be salvaged, burned or treated with ethylene dibromide (EDB).

Beetle populations continued to increase, outpacing suppression and prevention efforts. By 1980, significant lodgepole pine mortality was evident on the White River National Forest near Minturn and Eagle, Colorado. Evaluations were conducted in 1980 (Lister 1981) and 1982 (Averill and Lister 1982) covering the Holy Cross Ranger District, including the Holy Cross and Eagle's Nest Wilderness areas. Each evaluation predicted continued mortality from mountain pine beetle and each provided management recommendations for non-wilderness lands.

In 1982, the Summit-Upper Eagle - Integrated Forest Management Project (SUE-IFM) began. This cooperative effort between the USDA Forest Service, the Colorado State Forest Service, Summit and Eagle Counties, local communities and private landowners, was designed to address the beetle epidemic on both federal and private lands. On the National Forest, direct treatments included applications of EDB and lindane, and salvage logging. Indirect (preventive) treatments included harvest of susceptible stands (clearcuts and overstory removals) and precommercial thinning. Also, some high value campground trees were sprayed with the chemical, carbaryl, to prevent beetle attack. By 1985, mountain pine beetle populations had subsided.

In a post-suppression evaluation for the SUE-IFM project, Lessard (1985) recommended a shift from suppression activities to prevention activities, since the MPB outbreak had subsided. Lessard suggested the regeneration of approximately 14,000 acres each decade to "maintain" the lodgepole cover type in the analysis area and the regeneration of approximately 51,000 acres per decade to "substantially reduce the susceptibility of the cover type to mountain pine beetle." In follow-up, the area actually regenerated from 1984 to 1994 totaled only 1,201 acres.

In 1991, the Region 2 Forest Health Management staff was asked by the White River National Forest to:

a) evaluate past management activities,
b) determine the potential for future MPB outbreaks, and
c) make recommendations for the management of susceptible lodgepole pine stands.
d) determine whether treatments over the past decade have been successful in minimizing resource losses to mountain pine beetle.
e) determine whether localized large-scale treatments within a watershed resulted in unacceptable cumulative impacts to resource values.
f) determine if silviculture treatments other than clearcutting would be equally effective in meeting the objectives of the SUE-IFM Project.

Meetings were held in 1992-93 to develop strategies to address this substantive request. As a result, an analysis area was selected for study that: a) encompassed several thousand acres; b) had existing stand exam data; c) had MPB-related management treatments and d) had additional forest health concerns. The area selected was the Piney Analysis Area. The recently-completed forest health assessment for the Piney Analysis Area (Angwin et al. 1996) addressed the aforementioned items, a-d and f.

The assessment a) concluded that past management activities have not minimized losses to MPB; b) identified large expanses (and types of stands) within the analysis area that remain most susceptible to MPB infestation; and c) made management recommendations to address integrated forest health concerns (combinations of MPB and/or diseases) that include options other than clearcutting.

As the Forest Health Assessment report for the Piney Analysis Area neared completion, mountain pine beetle activity in Eagle County began increasing once again. Recent increases in beetle-related tree mortality were reported by several sources, including Grieve (1995 and 1996) and S. Johnson (1996). The Town of Vail, the Colorado State Forest Service and the Holy Cross Ranger District expressed concern over increasing lodgepole pine mortality. Representatives (including Region 2 Forest Health Management) met in August 1996 to discuss the existing mountain pine beetle situation in Vail Valley. As a result, the area of greatest concern was identified (assessment area, Figs. 1 and 2) and an assessment was initiated to: 1) summarize all available data on existing mountain pine beetle activity in the Vail Valley area; 2) evaluate existing stand inventory data and determine current mountain pine beetle susceptibility; and 3) develop management recommendations based on the results of items 1 and 2.

II. METHODS

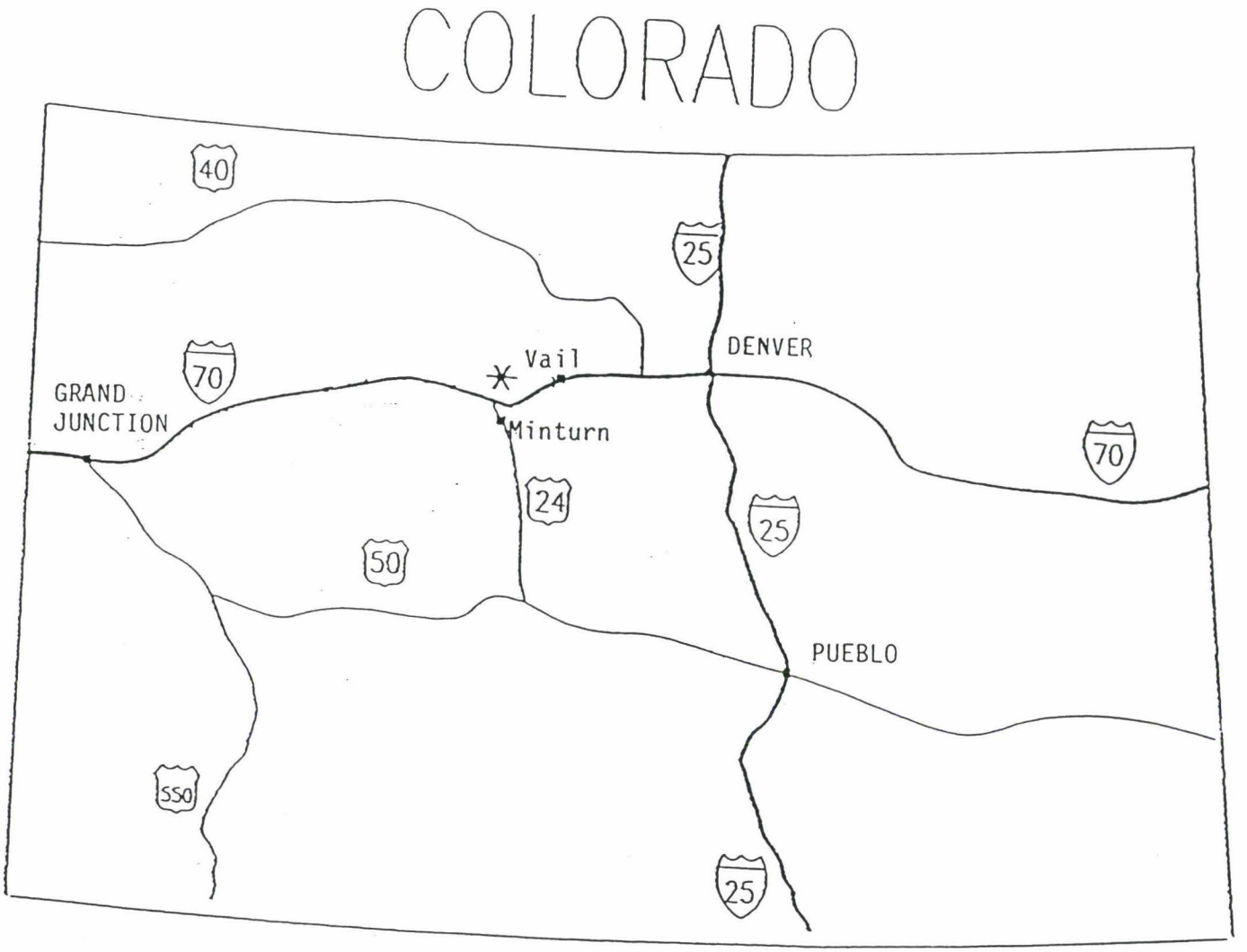
A. AERIAL SURVEY DATA

In August 1996, the USDA Forest Service (R2 Forest Health Management) completed an aerial survey of the assessment area and surrounding lands (E. Johnson 1996). Areas of MPB mortality in lodgepole pine were sketchmapped on topographic maps. This information was used to supplement on-site observations and photo interpreted data.

B. ON-SITE DATA

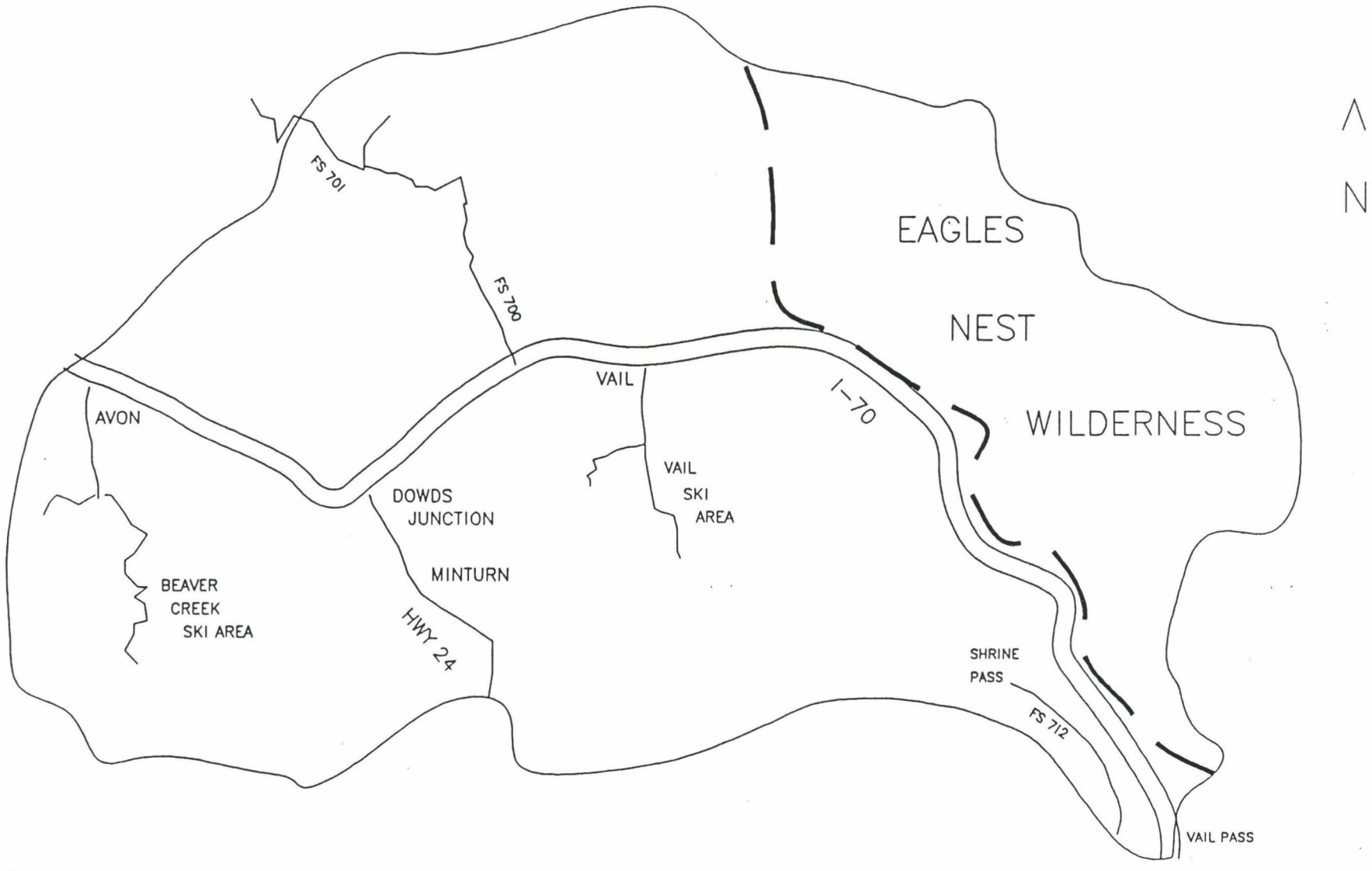
For several years, the High Country District of the Colorado State Forest Service has monitored certain mountain pine beetle sites in Summit, Eagle and Grand Counties (Grieve 1995 and 1996). The information from the summary reports of 1995 and 1996 was an integral part of the assessment of current MBP activity. All four of the "major areas of MPB activity" in Eagle County in 1996, as identified by Grieve, fall within the assessment area.

Figure 1. Vicinity Map.



* Vail Valley Mountain Pine Beetle Assessment Area.

Figure 2. Vail Valley Mountain Pine Beetle Assessment. Project Area Map.



LEGEND

Wilderness Boundary

SCALE 1/2 INCH = 1 MILE

C. AERIAL PHOTOGRAPHY ACQUISITION AND INTERPRETATION

A color infrared (CIR) imagery mission was co-funded by the Town of Vail and the Holy Cross Ranger District. The goal was to obtain CIR imagery of the entire assessment area at an approximate scale of 1:12,000. CIR was chosen instead of standard color due to its unique color signature of beetle attacked trees and the resulting potential to identify pre-pre-visual symptoms. In October, 1996, members of the USDA Forest Service's Forest Health Technology Enterprise Team (FHTET; Fort Collins, CO) flew the CIR imagery missions. The color positive film was then processed into 9 inch by 9 inch photographs to facilitate interpretation activities. Photo interpretation to identify MPB-related tree mortality was completed by members of the Gunnison Service Center staff in December, 1996. Beetle-caused lodgepole pine mortality identified during photo interpretation was compared to existing occurrence data to refine and supplement these data.

D. MOUNTAIN PINE BEETLE SUSCEPTIBILITY

The susceptibility of lodgepole pine stands to mountain pine beetle infestation can be estimated from the average stand age and diameter and stand location (elevation and latitude) (Amman et al. 1977). Elevation and latitude are key factors in determining whether a lodgepole pine stand is susceptible to a mountain pine beetle epidemic. Amman et al. (1977) developed a general model for determining whether a stand is within a zone of potentially heavy, moderate or light infestation. By multiplying the risk factors (1 = low; 2 = moderate; and 3 = high) for elevation and latitude, average age, and average d.b.h., a stand's susceptibility index is determined as follows:

a) Elevation (feet)[1]	b) Average Age (years)	c) Average d.b.h. (inches)
> 10,400 (1)	< 60 (1)	< 7 (1)
9,400 - 10,400 (2)	60 -80 (2)	7 -8 (2)
< 9,400 (3)	> 80 (3)	> 8 (3)

[1] Elevation risk values vary with latitude. Values noted are for the White River National Forest.

Susceptibility Index (a x b x c): 1-9 = Low; 12-18 = Moderate; 27 = High.

All lodgepole stands with sufficient data were rated for mountain pine beetle susceptibility according to this method. The age of stand exam data varies. Collection dates range from July, 1976 to September, 1994 (Piney Analysis).

III. RESULTS

A. AREA, OWNERSHIP AND FOREST COVER

The assessment area totals approximately 111,900 acres. Tables 1 and 2 show the ownership and forest cover summaries. Approximately 78 percent of the area (> 87,000 acres) is National Forest System (NFS) land. Of this, 19,924 acres are within the Eagle's Nest Wilderness. Private and state lands make up 21 and 1 percent of the area, respectively. Approximately 79 percent of the area is forested by aspen, Douglas-fir, lodgepole pine and spruce-fir stands. Of that, 31 percent (approximately 34,400 acres) are lodgepole pine, the local host species of mountain pine beetle.

Table 1. Summary of land ownership for the Vail Valley Mountain Pine Beetle Assessment area.

Ownership[1]	**Acres (% of Total)**
State	608 (1)
Private	23,955 (21)
National Forest (NFS)	87,351 (78)[2]
Total	**111,914 (100)**

[1] Source: RMRIS

[2] 19,924 ac. of the total is wilderness (=18 % of total, 23 % of National Forest ownership).

Table 2. Summary of forest cover types for the Vail Valley Mountain Pine Beetle Assessment area.

Cover Type[1]	**Acres (% of Total)**
Non-Forested[2]	23,998 (21)
Aspen	19,169 (17)
Douglas-fir	481 (< 1)
Lodgepole Pine	34,427 (31)
Spruce-Fir	33,839 (30)
Total	**111,914 (100)**

[1] Source: RMRIS

[2] Includes water, rock grass, forb and shrub cover.

A portion of the Piney Analysis Area falls within the boundary of this assessment (Figure 3). The area of overlap is north of Interstate 70, from Avon, CO north and east to the boundary of the Eagle's Nest Wilderness. Therefore, some information from the Piney Analysis was beneficial to this assessment effort.

B. LODGEPOLE PINE COVER TYPE

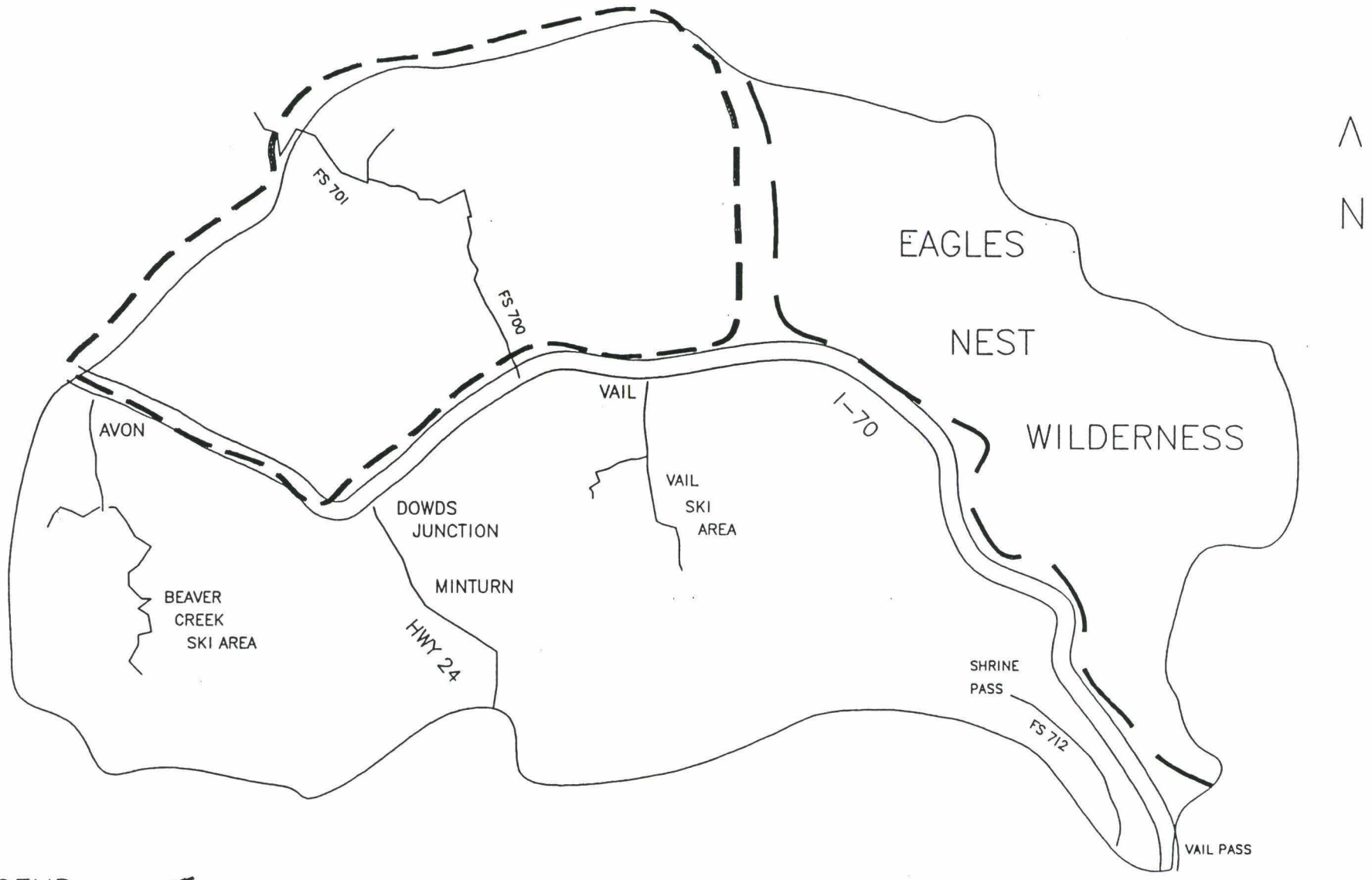
The focus of this assessment is the lodgepole pine cover type and associated mountain pine beetle incidence and susceptibility. There are 799 Rocky Mountain Resource Information System (RMRIS) sites and eleven different management emphasis areas applied to this cover type (Table 3). Skiing (etc., 1B), semi-primitive motorized recreation (2A) and wood fiber production (7E), combined, account for almost one-half (49%) of the sites within the lodgepole pine cover type. Fifteen percent of the lodgepole cover type sites have Wilderness emphases (8 A-C). As per Table 1, 18 % of the assessment area is designated Wilderness.

Table 3. Number of RMRIS sites per Management Area, lodgepole pine cover type, Vail Valley Mountain Pine Beetle Assessment Area.

Mgmt. Area	# of RMRIS Sites (% of Total)
1B Skiing, hiking, mtn. biking, horseback riding, hunting and assoc. development	102 (13)
2A Semi-primitive motorized recreation	138 (17)
2B Rural and roaded-natural recreation	51 (6)
3A Semi-primitive, non-motorized recreation in roaded or non-roaded areas	89 (11)
4B Habitat for Mgmt. Indicator species	66 (8)
5A Non-forested big game winter range	14 (2)
5B Forested big game winter range	43 (5)
7E Wood fiber production	149 (19)
8A Pristine Wilderness	6 (1)
8B Semi-Primitive Wilderness	37 (4)
8C Primitive Wilderness	76 (10)
Undesignated[1]	28 (4)
Total	**799 (100)**

[1] Management Area not noted in RMRIS database.

Figure 7.
Overlap between Piney Analysis Area and Vail Valley Mountain Pine Beetle Assessment Area.



The tree size class distribution for the lodgepole pine cover type is noted in Table 4. The "large" and "very large" classes represent stands where the majority of the trees are larger than 9.0 inches d.b.h. These trees represent the highest MPB susceptibility in regard to diameter (Amman et al. 1977). These two classes combined represent approximately 61 percent of the lodgepole cover type. This estimate is conservative, as the upper end of the "medium" size class also includes highly susceptible trees (> 8 inches).

Table 4. Tree size classes for the lodgepole pine cover type, Vail Valley Mountain Pine Beetle Assessment area.

Size Class [1,2]	**Acres (% of Total))**
Non-Stocked	596(2)
Established	403 (1)
Small	590 (2)
Medium	11,797 (34)
Large	20,975 (60)
Very Large	66 (<1)
Total	**34,427 (100)**

[1] Source: RMRIS
[2] Definitions:
Non-stocked - site not currently vegetated with the cover type, but is expected to develop seedlings.
Established - majority of trees are seedlings (up to 4.9 inches in diameter).
Small - saplings and seedlings; most are saplings (1-4.9 inches in diameter).
Medium - based on basal area, majority of live trees are 5-8.9 inches in diameter.
Large - based on basal area, majority of live trees are 9 inches and larger. In that group, the majority of the basal area is live trees 9-15.9 inches in diameter.
Very Large - majority of basal area is live trees, 16.0 inches in diameter and larger.

Lodgepole pine age class groups (as per Amman's MPB susceptibility rating) are shown in Table 5. Eighty-six percent of lodgepole pine stands (19,243 ac.) with "average age" data are over 80 years old, the most susceptible age group to mountain pine beetle infestation. Similar to the findings of the Piney Forest Health Assessment (Angwin et al. 1996), the paucity of lodgepole pine stands less than 80 years old indicates a significant deviation from the desired future condition stated in the White River National Forest Plan.

Table 5. Summary of age class groups (as per Amman's MPB risk rating (Amman et al. 1977)) for the lodgepole pine cover type, Vail Valley MPB Assessment Area.

Age Group (years)	Total Acres (% of Total)
< 60	1252 (6)
60 - 80	1853 (8)
> 80	19,243 (86)
Total	**22,348 (100)**

C. MOUNTAIN PINE BEETLE ACTIVITY

One objective of the assessment was to bring together all available data on existing mountain pine beetle activity in the Vail Valley area. These data came from 3 sources: 1) aerial survey sketchmaps (USDA Forest Service, 1996); 2) on-site monitoring (Colorado State Forest Service, 1995-96); and 3) color infrared photography obtained in October, 1996.

1. Aerial Survey Information

In August 1996, the USDA Forest Service (R2 Forest Health Management) completed an aerial survey of the assessment area and surrounding lands. Areas of MPB mortality in lodgepole pine were sketchmapped on topographic maps. This and existing information has been used by the High Country District, Colorado State Forest Service, to monitor individual sites of MPB activity.

2. On-Site Information/Monitoring

From 1995 to 1996 in Eagle County, Grieve (1996) reported a 123 percent increase in the number of trees infested (from 1021 to 2277 trees) and a more than three-fold increase in the number of acres of MPB activity (from 42.7 to 131.99 ac.). As of 1996, Grieve noted 28 active MPB sites on approximately 132 acres. All four of the "major areas of MPB activity" identified by Grieve in Eagle County in 1996, fall within the assessment area. These areas include Gore Creek Campground, the area immediately up slope from the Vail Golf Course, the Meadow Mountain area and Eastern Eagle-Vail. Grieve's MPB observations for Eagle County in 1996 are summarized in Table 6.

Table 6. Summary of on-site MPB monitoring in Eagle County, 1996 (Source: Grieve 1996, CSFS).

Current Active Sites:	28
New Sites:	16
Inactive Sites[1]	6
Currently Infested Trees	2277
Infested Acres	131.99 (Private 8.99; NFS 123.0)

[1] Due to depletion of large diameter lodgepole pine.

3. Photo Interpretation

Because of differences in elevation, the scales of the CIR photos range between approximately 1:12,000 (higher elevations) and 1:16,000 (lower elevations). MPB-killed trees were readily apparent, especially at the larger scale. Due to a combination of time of year (October) and possibly time of day, shadows were evident on the north aspects of some steep terrain. These shadows prevented the interpretation of beetle activity on a very small portion of the total assessment area. For these areas, beetle activity was noted from available aerial survey and on-site data.

The assessment area was covered by fourteen photo flight lines. Because of inclement weather, two of the flight lines were completed in two segments each.
Aerial photo end and side lap (overlap between photos in a flight line and photos of adjacent lines, respectively) were sufficient for stereo viewing of all parts of the assessment area.

The signature of mountain pine beetle in lodgepole pine was identified and verified by comparison to areas of known beetle activity. Areas of dead trees were identified on photos as distinct polygons. These polygons were then transferred to 7 1/2 Minute Quadrangle maps (1:24,000).

4. Mountain Pine Beetle Activity (Total, All Sources)

Composite maps (1:24,000 Quads) were developed incorporating aerial survey, on-site and photo interpreted data. Elevations in the assessment area range from approximately 7400 to 12,000 feet. Most mountain pine beetle activity occurs between 8200 and 9600 feet. The largest concentrations of beetle activity are in or immediately adjacent to the Interstate 70 corridor. Many "spots", though highly visible from I-70, are on steep terrain with difficult access. This is significant, as aesthetics are among the major concerns related to the current beetle activity in Vail Valley.

In combining all of the mountain pine beetle activity information available, the total for the assessment area in 1996 was estimated to be approximately 208 acres (Figure 4). Of this total, approximately 15 acres are private and state land and approximately 193 acres are National Forest System (NFS) lands. Of the 193 acres on NFS lands, 42 acres are in the Eagle's Nest Wilderness. A summary of bark beetle activity by RMRIS Location-Site is noted in Appendix A. Beetle activity identified during CIR photo interpretation work will be validated, as necessary, by on-site evaluation.

D. MOUNTAIN PINE BEETLE SUSCEPTIBILITY

Total acres of lodgepole pine: 34,427 (Table 3.)
Total acres of lodgepole pine with inventory data: 7282

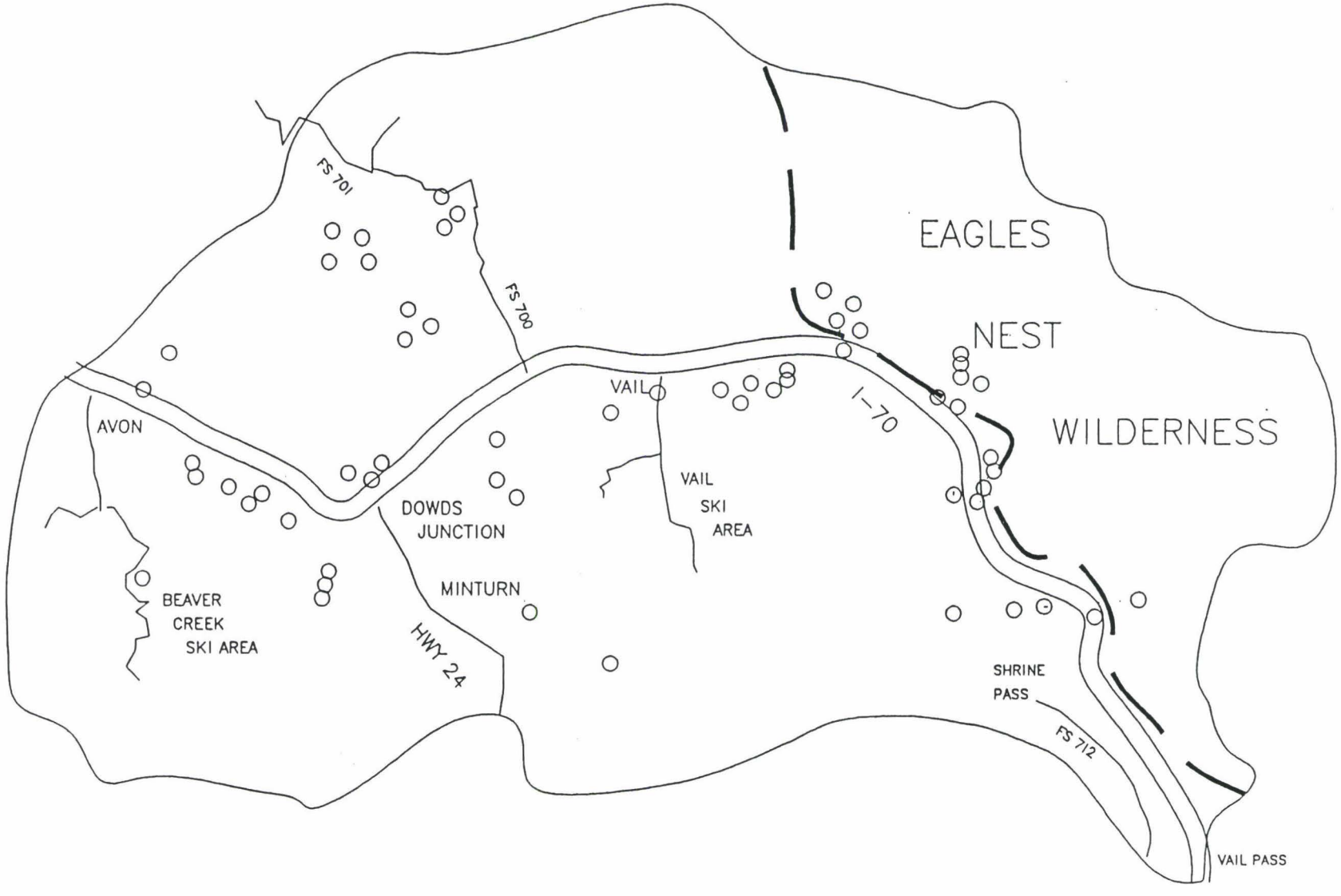
Susceptibility Rating	**# of Stands**	**Acres (% of Total)**
Low	7	126 (2)
Moderate	144	6744 (93)
High	14	412 (5)
Total	**165**	**7282 (100)**

It may not be valid to assume that available stand exam data adequately represents the entire lodgepole pine cover type. If it were, then 98 % of the 34,427 could be considered as being at moderate-high risk to bark beetle infestation. Although area-wide inventory information is lacking, it is important to note that the RMRIS data available indicates that most of the lodgepole landscape falls into the age (87 % > 80 years) and size (61 % large and very large; > 9 inches) classes most susceptible to MBP infestation. This information alone indicates that a large-scale bark beetle disturbance seems likely. Elevation appears to be the factor that limits higher MPB susceptibility ratings across the landscape.

Because a bark beetle outbreak is the result of a number of different factors related to the beetle, its host and its environment, it is almost impossible to determine the timing of an outbreak. Susceptibility ratings only identify a stand's propensity for infestation, not the timing thereof.

Fig e 4.

Areas of major mountain pine bettle activity within the Vail Valley MPB Assessment Area, 1996.



LEGEND o MPB Activity, 1996

SCALE 1/2 INCH = 1 MILE

E. MODELING MOUNTAIN PINE BEETLE-CAUSED MORTALITY

Although stand inventory data for the assessment area is limited, additional information on potential MPB-caused tree mortality was desired. The recent completion of the Forest Health Assessment for the Piney Analysis Area (adjoining and partially overlapping this assessment area) provided additional data for a limited assessment of potential MPB-caused mortality. As part of the Piney Forest Health Assessment, stands representing the three MPB risk classes (low, moderate and high) were modeled using the Mountain Pine Beetle Variant of the Forest Vegetation Simulator (growth and yield model).

Three of the stands modeled for the Piney assessment also fall within the boundaries of this assessment area and the results of these three are presented here (Table 7; from Angwin et al. 1996): It is dangerous to extrapolate from such a small sample. However, in the context of this assessment and with the understanding that additional interdisciplinary analysis is necessary before management actions are implemented, the following should be considered: a) all stands, regardless of rating showed some degree of mortality; and b) growth loss due to mortality (quantified as volume reduction) would be considered significant in a minimum of three of the four examples.

Table 7. Results of Forest Vegetation Simulator/Mountain Pine Beetle Model runs (from Angwin et al. 1996).

1. Stands in FVS-MPB Model Simulations

Stand ID	Stand Age	LPP (% TPA)	MPB Rating
107202-6	81	91	Low
107003-17	89	61	Mod
107004-7	75	93	Mod
107001-11	85	62	High

2. Volume Loss in 10 Cycles, MPB Outbreak Starting in Year 1994.

Stand ID	Cubic Volume without Outbreak	Cubic Volume with Outbreak	Reduction in volume (%)
107202-6	4635	2377	49
107003-17	7048	6221	12
107004-7	6739	5362	20
107001-11	7700	5720	26

IV. CONCLUSIONS

Approximately 98 percent of inventoried lodgepole pine stands have a moderate-high risk of mountain pine beetle infestation. These old, larger diameter (> 7 in.) stands dominate the lodgepole pine landscape. As of 1996, 208 acres of ongoing mountain pine beetle activity were identified in the assessment area. Although this beetle activity does not equate to a large-scale epidemic, available data indicate that mountain pine beetle activity has increased for several consecutive years and will likely continue to do so. Even if the current beetle activity were to subside, the beetle-susceptible stand conditions remain and a large-scale outbreak appears inevitable.

Susceptibility ratings identify a stand's propensity for infestation, not the timing thereof. Therefore, silvicultural manipulations of stands are desirable to provide longer term protection from future bark beetle outbreaks, whenever they might occur.

Modeling of beetle-caused tree mortality, though not a direct estimate, does indicate that impacts to many lodgepole pine stands could be substantial, preventing the realization of numerous resource management goals.

Past (and most likely future) stand management activities have not occurred at a scale large enough to significantly reduce potential mountain pine beetle mortality across the landscape. Therefore, some amount of mortality will have to be accepted. Where such mortality is deemed unacceptable, management resources should be focused to first address existing mountain pine beetle activity, and second, to implement preventive actions to protect the valued resource.

Because disturbance is a driving element for lodgepole pine forests, it is conceivable that an event such as a wildfire could occur and alter the present stand conditions on a large, stand-replacing scale. Such are the occurrences that allowed the establishment of the expanse of seral lodgepole present today. Because silviculture activities cannot be accelerated to the level needed to address the current landscape-level beetle risk, prescribed fire must also be used to develop the mosaic of desired age and size classes as per the White River National Forest Plan (lodgepole pine type, desired future condition).

V. RECOMMENDATIONS

This assessment was not designed to develop site-specific management recommendations. Such a step would be the next obvious one and would include multi-disciplinary interaction and analysis. Given the evaluation of existing beetle activity and host susceptibility, this assessment provides information specific enough to suggest management options for portions of landscapes, such as Management Areas.

A. PRESCRIBED FIRE

1. Prescribed Natural Fire

Because of the remote nature of portions of the assessment area north of Interstate 70, opportunities to reintroduce fire to the landscape should not be overlooked. Prescribed natural fire may be especially appropriate in the Eagle's Nest Wilderness and portions of other remote Management Areas (e.g. 3A, 5A and 5B). A prescribed natural fire plan is currently being prepared for the Eagle's Nest Wilderness. Ownership patterns are intermingled, even in proximity to the Wilderness, which may complicate implementation of this alternative.

2. Prescribed Fire

At present, wildlife habitat enhancement burns are planned for portions of the Booth Creek Area (Johnston 1997). These burns will not influence mountain pine beetle activity or the lodgepole pine type to a large degree, but they are examples of the type of management that must become a common practice in the assessment area. Smoke's impact to air quality will complicate the reintroduction of fire, but such reintroduction is one necessary tool to alter the current lodgepole pine conditions across the landscape. Prescribed fire is applicable in a number of Management Areas and could achieve multiple goals such as wildlife habitat/diversity enhancement, and fuels and bark beetle risk reduction. Although such cover type alteration is necessary to reduce future mountain pine beetle losses, prescribed fire of the scale proposed will also impact aesthetics.

B. SILVICULTURE

Stand manipulation through silviculture provides the most effective and long-lasting benefits where certain mountain pine beetle impacts are undesirable (Amman et al. 1977; McGregor and Cole 1985); e.g. private lands and portions of the National Forest with 7E (wood fiber production) management emphasis (Table 3).

These treatments could also be used in suppression efforts within the Wilderness, but only in emergency situations to protect surrounding resources. Evenaged and unevenaged management systems may be used to reduce stand susceptibility (Amman et al. 1989). Where other tree species can be favored, utilizing mixed species stands to reduce MPB susceptibility is a viable option (Mitchell, 1989).

The efficacy of thinning to prevent future mountain pine beetle losses is well documented (Cole 1978; Gibson 1989; Cole 1989). Detailed density suggestions will not be presented here, because their determination is based on a myriad of factors specific to the stand and related management goals. However, it is important to note that density may have to be reduced below a susceptibility goal (e.g. 120 sq. ft. BA), in order to maintain the "beetle proofing" until the next entry. Because of the lack of age and size class diversity in the lodgepole cover type, numerous opportunities for thinning are available in the assessment area.

Because beetle-related tree mortality and relative stand density have a nonlinear relationship in lodgepole pine (Anhold and Jenkins,1987), Anhold and Long (1996) identified "high" and "low" stand density indices to reduce MPB mortality over a rotation. Management schemes to maintain these indices are best applied to younger stands, thus they have little application potential due to the paucity of young stands in the assessment area. This information is noted here, however, so that it can be evaluated among future management options.

Ideally, silvicultural efforts over time should establish a mosaic of age classes, stocking levels and species mixes over the landscape. This strategy requires that many silvicultural tools be used (including fire) and that prescriptions must vary with stand conditions (Gibson 1989).

C. PHEROMONES

Pheromones are behavioral chemicals produced by bark beetles. They are grouped into two general categories, aggregates and anti-aggregates. Aggregate pheromones show some promise as tools to manage mountain pine beetle-caused tree mortality, though their operational use to date has been limited. Pheromones are used most effectively in situations like that in Vail Valley, where beetle populations are increasing, but have yet to reach epidemic proportions. The results of pheromone deployment are often difficult to predict. Therefore, planning and implementation of pheromone work should be conducted by trained professionals.

Opportunities exist within the assessment area to test aggregate pheromones in conjunction with salvage logging to address existing beetle activity. This should be considered in Management Areas such as 7E (wood fiber production), where roaded access exists. In areas without access, such as the steep terrain in the I-70 corridor (Mgmt. Areas 3A, 4B, 5A and 5B), opportunities exist to deploy pheromones in an attempt to confine losses to a specific area.

As noted previously, this is where professional expertise is needed in planning and deployment. Pheromone use in Wilderness settings is not recommended, as it may be inconsistent with current management direction. Although pheromones may have some application in the assessment area, they require detailed specialist involvement and they do nothing to address the susceptible condition of lodgepole pine stands.

D. TREATMENT OF INDIVIDUAL HIGH-VALUE TREES

Tree boles can be treated with the chemical, carbaryl, to prevent MPB attack for one, possibly two years. The chemical is typically applied by ground-based spray equipment. The boles of host trees are treated to either a height of thirty (30) feet above the ground or to a top diameter of six (6) inches, whichever comes first. This treatment may be desirable in some developed recreation sites and to a lesser extent in residential settings. Such applications can be done by individual property owners, but are best implemented by licensed and certified professionals. Although this treatment is effective in certain settings, it does nothing to address the beetle-susceptible condition of lodgepole pine trees. Therefore, it will have to be repeated throughout the duration of an outbreak.

VI. ONGOING AND FUTURE WORK

1) Ground-truthing of newly identified (photo interpreted) mountain pine beetle spots will occur during the summer of 1997 (cooperative effort between Gunnison Service Center and the Colorado State Forest Service). Beetle activity and spot status (active/inactive) data will then be revised .

2) An aerial survey of the area will again be conducted in 1997 to identify trees attacked in 1996 (the fading crown "signature" may not have been evident on the 1996 CIR photos). Beetle occurrence data will be updated following this survey and following the implementation of management activities.

3) Assessment cooperators will continue to monitor beetle activity and should initiate a coordinated effort to plan and implement suppression and prevention activities in priority areas. The many management efforts that are already being implemented (by the CSFS and the Town of Vail) may serve as a foundation.

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IX. APPENDIX A

Mountain Pine Beetle Activity in the Vail Valley Assessment Area, 1996
RMRIS Location-Site Information

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Mountain Pine Beetle Activity in the Vail Valley Assessment Area, 1996[1]
RMRIS Location-Site Information

Quad Name	Loc-Site(s)	Comments/ Mgmt Area
Vail West	101319 - 13	few, scattered trees; 2A
Grouse Mtn.	102801 - 90	Beaver Cr. Ski Area; 1B
Minturn	102901 - 02,100 (pvt)	few, scattered; 5B
Minturn	103001 - 07,13,14,100 (st)	few, scattered; 5B&4B
Minturn	103101 - 04,17,18	large concentration; ?
Minturn	103102 - 03,25	scattered; 4B
Minturn	103103 - 8,9	concen. above Minturn; 4B
Minturn	103104 - 30,33	few, scattered; 4B
Minturn	105809 - 13	< 3 trees; 3A
Minturn	105902 - 18	scattered, near Lions Head; 5A
Vail East	106002 -18	< 3 trees; 3A
Vail East	106004 - 2,3,7,11	1B
Minturn	106005 - 15,23,24,100 (pvt)	scattered; pvt < 3 trees; 1B
Vail West	106005 - 101 (pvt)	scattered; n/a
Vail East	106006 - 5,6,8,9,10,11,12,	Vail Ski Area & above
	13,14,21	golf course; 3A, 1B
Red Cliff	106101 - 100 (pvt)	scattered; n/a
Red Cliff	106102 - 02	< 3 trees; 7E
Red Cliff	106202 - 10,15,18	some concen. + scattered; 7E
Vail Pass	106205 - 01	w side of I 70; ?
Vail Pass	106207 - 39	adj. to wilderness; 2B
Vail East	106301 - 39,40	Gore Cr.; 2A
Vail East	106401 - 22,23	Gore Cr.; 2A
Vail East	106501 - 32,102 (pvt)	2A
	21,22,26,27 (wild)	8C
Vail East	106601 - 45,46,101 (pvt)	2B
	36,37,39- 42 (wild)	concentration - wild; 8C
Vail East	106801 - 26	< 5 trees; 2A
Vail West	107001 - 12,14,17,20,32	scattered; 2A
Vail West	107002 - 19,21,22,23,28	scattered; 7E & 2A (28)
Vail West	107004 - 3,6,14	3,6 concen. above road; 7E
Vail West	107101 - 23,39	< 5 trees; 2A
Vail West	107102 - 06,26,27,35,37	few, scattered; 2A
Vail West	107201 - 11,20,21	concentration; 2A
	4,10,23	scattered; 2A
Vail West	107202 - 100 (pvt)	2 concentrations; n/a
	02	< 3 trees; 2A
Minturn/Vail W.	107203 - 3,4	2 concentrations; 2A
	100, 102 (pvt)	scattered; n/a
Vail West	107302 - 01	few, scattered; ?
Vail West	107303 - 02	few, scattered; 7E
Vail West	107304 -02,03	scattered; 2A
Vail West	107305 - 01	few, scattered; 7E

[1] Beetle activity identified during CIR photo interpretation work is to be validated, as necessary, by on-site evaluation.

wild = wilderness
concen. = concentration of dead trees
scattered = scattered dead trees

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